

Drying dynamics, Physicochemical properties and Sensory Analysis of Sweet Red Pepper Paste

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Abstract— Sweet red pepper (SRP) paste is a traditional food of the region made using *Capsicum annuum* with the purpose of using it beyond the harvesting season. A method combining the traditional methods and the industrial method was followed taking into consideration heat or non-heat treatment and each was with or without salt addition, with or without adjustment of pH using citric acid. Within the same drying temperature (50°C or 70°C) the moisture loss and slope were significantly higher in the first 7 drying hours compared to the rest 16 hours, but within these timeslots the water loss did not differ significantly. The water activity of SRP paste was around 0.98 with a total solid content of around 20%. The addition of citric acid to SRP paste will be classified as high acid food while those with no citric acid addition will be classified as low acid food. There was no significant difference concerning color, odor and Non Mouth Texture between all heat-treated (blaze heating) and non-heat treated, pH adjusted and non-pH adjusted and salted and non-salted SRP paste. As for the overall acceptability the non-heat treated and the non-heat treated and pH adjusted SRP paste scored significantly the lowest. There was however no significant difference between all the other heat treated and non heat treated, pH adjusted and salted and non-salted SRP paste. This information can be used to adjust the water activity (time of drying) and pH to change the kinetics of deterioration during SRP paste storage.

Keywords— Sweet red pepper paste, *Capsicum annuum*, moisture loss, high acid food, low acid food, water activity.

I. INTRODUCTION

Transferring vegetables into pastes, like tomato paste, is an old method done to enable their consumption outside of their production season. One of these vegetables is sweet red pepper (SRP) or *Capsicum annuum* L from the Solanaceae family (Pérez-Gálvez, Jaren, & I. Mínguez-Mosquera, 2007). They are consumed for their distinctive nice red color, taste and odor (Mínguez-Mosquera, Pérez-Gálvez, & Hornero-Méndez, 2008) (Arimboor, Natarajan, Menon, Chandrasekhar, & Moorkoth, 2015) (Lucio-Juárez, 2013).

The powder of sweet red pepper is known to possess some beneficial effects on the gastro intestinal track (GIT) and was reported to destroy some GIT-related pathogenic bacteria (Olatunji & Afolayan, 2018) (Kumar, Sharma, Chattopadhyay, & Chakraborty, 2012).

A study was conducted by Hwang et al (Hwang, Shin, Lee, Lee, & Yoo, 2012) aimed to assess the effect of different processing techniques such as boiling, roasting, stir frying and steaming showed that the significantly highest loss was due to boiling and the processing method

applying dry heat was the most favorable in terms of nutrient and antioxidant retention.

The traditional production method of SRP paste involves washing, deseeding, destemming, grinding and sun drying for few days (Sermenli & Mavi, 2010) (Bozkurt & Erkmen, 2005). The industrial method, however, was developed involving the same steps except for the sun-drying which was replaced by concentration using boiling (Bozkurt & Erkmen, 2004). While this process satisfies the hygienic requirement of the customers it led to the loss of the typical flavor of the SRP paste (Bozkurt & Erkmen, 2004). In their study, (Gogus, Ozel, Keskin, Yanik, & Lewis, 2015) concluded that pepper paste produced using traditional ways had superior characteristics to the paste produced following the industrial method. They registered lower concentrations of degradation and browning products resulting from concentration process and more desirable organoleptic properties. Interestingly, Gogus et al., (Gogus, Ozel, Keskin, Yanik, & Lewis, 2015), stated that the pepper paste produced in a traditional way had aromatic

compounds (aldehydes, alcohols, and ketones) which were not detected in either the fresh pepper or the industrially produced paste.

Thus the merging of the industrial method, due to hygienic standards, and that of the traditional method, due to flavor, is a need. The main factor for this combination is to study the drying dynamics of the reduced temperature abuse due to boiling and the usage of a temperature that would allow the development of flavor of the SRP paste in a hygienic way. Furthermore, the physicochemical properties involved with SRP paste product such as pH, moisture content, and water activity were recorded. In addition to that, sensory analysis was conducted to assess the overall acceptability of the produced SRP paste.

II. MATERIAL AND METHOD

2.1. Sample Preparationⁱ

Ripe fruits of sweet red pepper were purchased from the local market. The fresh peppers were washed, cut into pieces, the white skin and the inside seeds were removed and was separated into 3 replicates.

Furthermore, part of the cut SRP was subjected to blaze heating for 12 minutes and other part was left with no heat treatment.

Part of the paste produced from the above procedures had salt (NaCl) added (2%) and other part had no salt in it (Henney JE, 2010). Same procedure was done with citric acid where part of the paste had no citric acid and other part had citric acid added till the pH of the paste was lower than 4.2. Other part had both Salt and citric acids. In addition to that, potassium sorbate was added to all at 0.5% (Fig. 1)

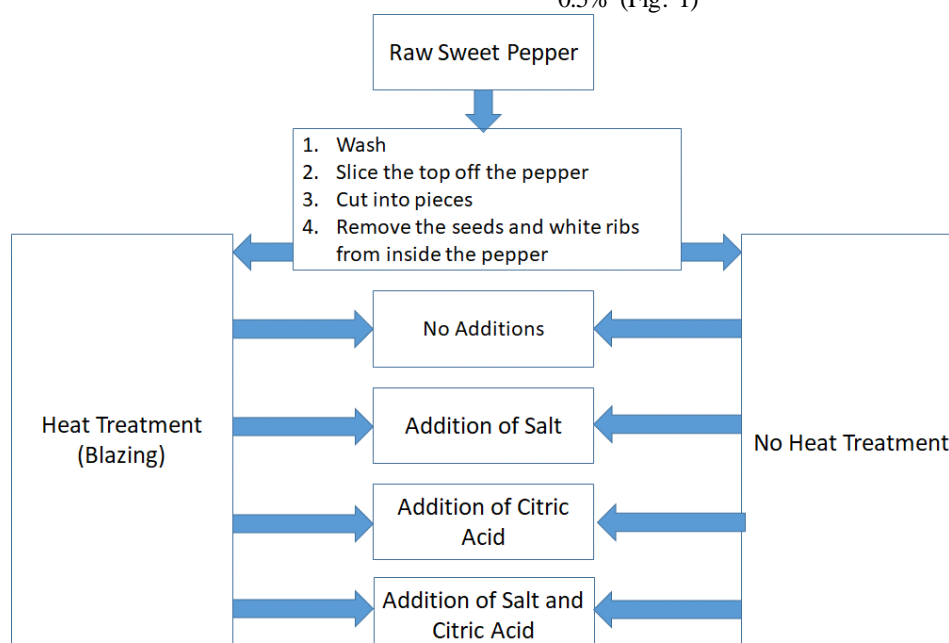


Fig.1 Sweet Red Pepper Sample preparation

2.2. Methods

Moisture content: Drying Oven and Balance method was used for moisture content determination. The oven used was Contherm designer series (Contherm Scientific LTD) following the IS 11623: 1986.

Total Solids: Total solids was measured by subtracting the percent of moisture content from 100.

Weight determination: Weight was measured using Analytical Balance MS304TS/00 with 320 g capacity and 0.1 mg readability.

pH analysis: Microcomputer based pH/conductivity/TDS/salinity and temperature pocket meter Model pH/EC80 was used to measure the pH (Jenco VisionP).

Water activity: It was determined using Pawkit water activity meter. Sample were flattened to cover the bottom of the cup and then water activity was measured at room temperature (Suzann, 2010).

Ash Determination: Ash was determined using the AOAC 942.05 method.

Total dietary Fiber content: The samples were analyzed using the AOAC 992.16.

Hourly Water Loss: Hourly Water loss was determined by subtracting the weight of the sample at a given hour from the initial weight of the sample at the previous hour. This protocol was followed under both 50°C and 70°C.

Slope of moisture content versus time: the slope was measured using Microsoft excel 2016.

Note that the thickness of the sample to be dried was 1 cm with 20 to 30 cm trays. Sodium sorbate was added to the SRP paste to stop the molding when drying on 50°C but added to the 70°C in order to be able to compare them.

2.3. Statistical analysis

All tests and analysis were run in triplicates. In addition to that the GLM was used to study the difference between the different pastes concerning Initial Moisture content, moisture content, total solids, water lost rate, slope of moisture content versus time and the overall acceptability. General linear model (GLM) performed via SPSS (statistical Package for the Social Sciences, version 17.0) was used to study the difference in the physicochemical properties of the paste produced from the different procedures (water activity and pH) (Narain, 1985).

Furthermore, pairwise t-test was used to test for significance of slopes within the same drying temperature. In addition to that it was used on the water loss values within the same drying temperature to determine the hour at which the difference between the previous 3 hours and next 3 hours among the 24 hour scale was significant each time only changing one hour slot. In addition to that, it was used to test for the significant of the sensory attributes between the different treatments.

To measure the correlation between the sensory parameters and the heat treatment, salt level, citric acid level and overall acceptability spearman correlation for non-parametric data was use.

III. RESULTS

3.1. Fiber and ash content of SRP used

The fiber content was reported to 3.61% and the ash content was reported to be 8.56%. This was comparable to the values reported by Štursa who studies the nutritional content of paprika powder with 90 % total solids (Štursa, Diviš, & Pořízka, 2018).

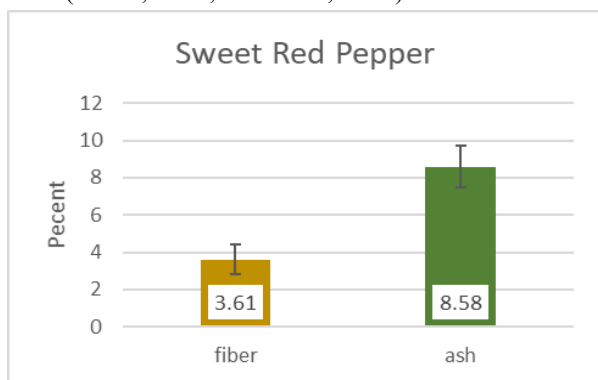


Fig.2: Fiber and ash content of the sweet red pepper used

3.2. Moisture content and total solids

The initial moisture content of the SRP used to study the dynamic of drying at two temperatures, namely 50°C and 70°C did not differ significantly (Table 1). Furthermore, at 6 hours drying at 50°C and 70°C the total solid contents of the SRP paste reached 15.87 and 21.49 respectively.

Table 1 Initial moisture content, moisture content and total solid content at 6 hours

| Parameter measured | Drying at 50°C | | Drying at 70°C | |
|---------------------------|--------------------|------|--------------------|------|
| | Mean | SE | Mean | SE |
| Initial Moisture content | 86.78 ^a | 0.40 | 88.10 ^a | 0.41 |
| Moisture content at 6 hrs | 84.13 ^a | 0.45 | 78.51 ^b | 0.95 |
| Total Solids at 6 hrs | 15.87 ^a | 0.45 | 21.49 ^b | 0.95 |

Among rows: means with different letters are significantly different

3.3. Water loss rate and slope of moisture versus time of SRP at 50°C and 70°C

Concerning the first parameter of drying dynamics, that is the amount of water lost per hour, and after realizing that the difference in rates did differ significantly only at the 7th hour and did not differ the hours before and after within the same drying temperature, the rate and consequently slope were measured in two time slots, namely the first time zone (first 7 hours) and the next time zone (next 16 hours).

Within the same drying temperature at both 50°C and 70°C, the water loss per hour during the first time zone was significantly higher from the water loss per hour at the second time zone with the values of the first time zone (Table 2).

Table 2 Comparing water loss and slope of moisture versus time within the same drying temperature

| Parameter measured | T | Time Zone | | | |
|------------------------|------|--------------------|-------|--------------------|------|
| | | 0 to 7 hours | | 8 to 24 hours | |
| | | Mean | SE | Mean | SE |
| Water loss per Hour | 50°C | -0.24 ^a | 0.003 | -0.20 ^b | 0.01 |
| | 70°C | -0.65 ^a | 0.01 | -0.25 ^b | 0.02 |
| Slope Moisture vs time | 50°C | -0.37 ^a | 0.01 | -0.66 ^b | 0.02 |
| | 70°C | -1.34 ^a | 0.07 | -4.70 ^b | 0.06 |

Among rows: means with different letters are significantly different

Concerning the slope of change of moisture versus time they, within the same drying temperature, the slope values

of the first time zone were significantly lower than the slope values of the second time zone (Table 2). This is

clear if we look at the curve of moisture content versus time at 70°C (Fig. 3).

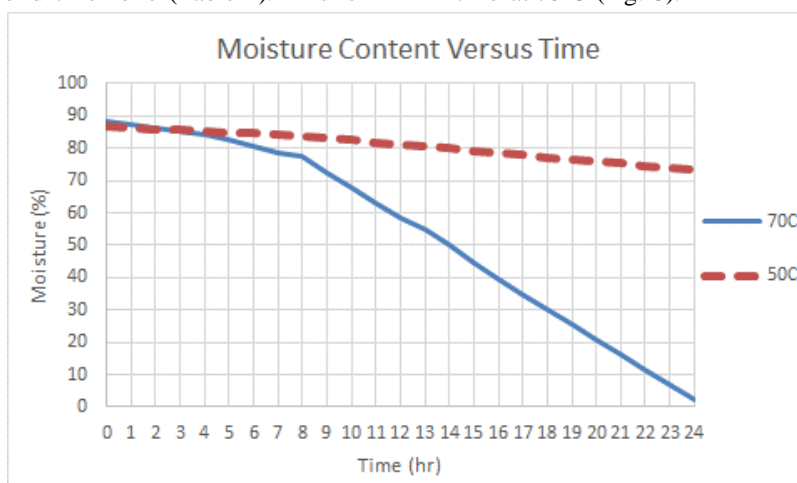


Fig.3 Moisture content of SRP versus time at different drying temperatures

As for the difference of water loss per hour between different drying temperatures results show that at 50°C was significantly higher than the one calculated for drying at 70°C. The significance at the next time zone, however, was not apparent between the water loss per hour at 50°C and 70°C (Table 3).

Table 3 Water loss rate and slope of moisture versus time at 50°C and 70°C

| Parameter measured | Time Zone | Drying at 50°C | | Drying at 70°C | |
|-------------------------|------------|--------------------|-------|--------------------|------|
| | | Mean | SE | Mean | SE |
| Water Loss per hour | 0 to 7 hr | -0.24 ^a | 0.003 | -0.65 ^b | 0.01 |
| | 8 to 24 hr | -0.20 ^a | 0.01 | -0.25 ^a | 0.02 |
| Slope Moisture per time | 0 to 7 hr | -0.37 ^a | 0.01 | -1.34 ^b | 0.07 |
| | 8 to 24 hr | -0.66 ^a | 0.02 | -4.70 ^b | 0.06 |
| Slope Moisture per Time | 0 to 24 hr | -0.58 ^a | 0.02 | -3.85 ^b | 0.02 |

Among rows: means with different letters are significantly different

Furthermore, comparing the slopes of moisture versus time showed, as expected that they were significantly higher at 70°C compare to those at 50°C irrespective of the time zone taken. To calculate the time needed to reach a certain moisture content we can use equation 1, 2, 3, 4, 5 and 6.

Equation 1 Moisture content versus time from 0 to 7 hours @50°C

$$\text{Moisture (\%)} = -0.369 \times \text{Time(hr)} + 86.75 \quad (R^2=99.91)$$

Equation 2 Moisture content versus time from 0 to 7 hours @70°C

$$\text{Moisture (\%)} = -1.339 \times \text{Time(hr)} + 88.86 \quad (R^2=99.91)$$

Equation 3 Moisture content versus time from 8 to 24 hours @50°C

$$\text{Moisture (\%)} = -0.369 \times \text{Time(hr)} + 86.75 \quad (R^2=99.91)$$

Equation 4 Moisture content versus time from 8 to 24 hours @70°C

$$\text{Moisture (\%)} = -4.698 \times \text{Time(hr)} + 114.81 \quad (R^2=99.90)$$

Equation 5 Moisture content versus time from 0 to 24 hours @50°C

$$\text{Moisture (\%)} = -0.579 \times \text{Time(hr)} + 86.75 \quad (R^2=97.01)$$

Equation 6 Moisture content versus time from 0 to 24 hours @70°C

$$\text{Moisture (\%)} = -3.846 \times \text{Time(hr)} + 100.10 \quad (R^2=96.77)$$

3.4. Water activity and pH of the different dried sweet red peppers recipes

The pH and water activity of the SRP paste was measured after 6 hours of drying at 70°C. The dry matter of the paste was chosen to be around 22%.

Table 4 pH and water activity of the product of sweet red pepper paste after 6 hours @ 70°C

| Treatment | pH | | Water Activity | |
|-----------|-------------------------------|-------|-------------------|-------|
| | Mean | SE | Mean | SE |
| OHT | 5.41 ^{ad} | 0.079 | 0.98 ^a | 0.008 |
| HTC | 3.94 ^b | 0.079 | 0.99 ^a | 0.008 |
| HTS | 5.28 ^a | 0.079 | 0.98 ^a | 0.008 |
| HTSC | 3.60 ^c | 0.079 | 0.97 ^a | 0.008 |
| NHT | 5.52 ^{d^e} | 0.079 | 0.97 ^a | 0.008 |
| NHTC | 3.88 ^b | 0.079 | 0.98 ^a | 0.008 |
| NHTS | 5.33 ^{a^e} | 0.079 | 0.98 ^a | 0.008 |
| NHTSC | 3.59 ^c | 0.079 | 0.99 ^a | 0.008 |
| Total | 4.57 | 0.079 | 0.98 | 0.008 |

Among columns: means with different letters are significantly different

O: Only, HT: Heat treated, C: With citric acid, S: With salt, N: not

The SRP pastes with added citric acid did possess a significantly lower pH than those with no citric acid. As for the water activity, no significant difference was recognized among all the treatments.

3.5. Sensory analysis.

Rank preference test was performed using 40 test subjects in order to score samples from the 8 recipes according to preference in terms of color, odor, flavor, mouth texture, non-mouth texture, texture uniformity and overall acceptability. The treated recipes were: only heat treated (OHT), heat treated with citric acid addition (HTC), heat treated with salt addition (HTS), heat treated with salt and citric acid addition (HTSC), no heat treatment with no additions (NHT), no heat treatment with citric acid addition (NHTC), no heat treatment with salt addition (NHTS) and no heat treatment with salt and citric acid addition (NHTSC) (Fig. 1).

3.5.1. Results of color, odor and flavor

The results of color score showed that heat-treated with salt and citric acid addition was significantly the lowest followed by the score of the no heat treatment with salt and no heat treatment with salt and citric acid addition while they did not differ significantly from the rest (Table 5).

As for the odor score the no heat-treated was the lowest but the significance between the different heat treatment was not clear between the heat treated or no heat treatment SRP paste (Table 5)

As for the flavor the scores of the no heat treated and no heat treatment with citric acid addition were significantly the lowest compared to the other treatment which did not differ from each other (Table 5).

Table 5 Scores of color, odor and flavor of SRP paste dried for 6 hours @ 70°C

| Treatment | Color | | Odor | | Flavor | |
|-----------|--------------------|------|--------------------|------|-------------------|------|
| | Mean | SD | Mean | SD | Mean | SD |
| OHT | 4.68 ^a | 0.47 | 4.55 ^{ab} | 0.71 | 4.20 ^a | 0.79 |
| HTC | 4.63 ^a | 0.49 | 4.63 ^{ac} | 0.59 | 4.10 ^a | 0.96 |
| HTS | 4.70 ^a | 0.46 | 4.70 ^a | 0.56 | 4.25 ^a | 0.98 |
| HTSC | 4.38 ^{bc} | 0.54 | 4.50 ^{ab} | 0.55 | 4.10 ^a | 1.06 |
| NHT | 4.75 ^a | 0.49 | 4.28 ^b | 0.82 | 3.40 ^b | 1.03 |
| NHTC | 4.60 ^a | 0.63 | 4.40 ^{bc} | 0.56 | 3.43 ^b | 1.03 |
| NHTS | 4.58 ^{ac} | 0.55 | 4.48 ^{ab} | 0.69 | 4.28 ^a | 0.88 |
| NHTSC | 4.58 ^{ac} | 0.59 | 4.55 ^{ab} | 0.68 | 4.18 ^a | 0.98 |
| Total | 4.61 | 0.54 | 4.51 | 0.65 | 3.99 | 1.02 |

Among columns: means with different letters are significantly different

O: Only, HT: Heat treated, C: With citric acid, S: With salt, N: not

3.5.2. Results of mouth feeling, non-mouth texture and texture uniformity

These three sensory attributes are important since they show how the SRP paste physically feel. Starting with the mouth feel and the non-mouth feel since the heat treatment with no salt or citric acid addition was significantly the lowest.

Furthermore, the no heat treatment with salt addition scored the highest in terms of texture uniformity. However, the significance was only their when compared with the no heat treatment with citric acid and no heat treatment with salt both of which scored the lowest.

Table 6 Scores of mouthfeel, Non-mouthfeel of SRP paste dried for 6 hours @ 70°C

| Treatment | Mouth feel | | Non-Mouth feel | | Uniformity of texture | |
|-----------|--------------------|------|--------------------|------|-----------------------|------|
| | Mean | SD | Mean | SD | Mean | SD |
| OHT | 4.20 ^{ab} | 0.68 | 4.32 ^{ab} | 0.61 | 4.72 ^{ac} | 0.45 |
| HTC | 4.55 ^{bc} | 0.59 | 4.57 ^{bc} | 0.54 | 4.75 ^{ac} | 0.43 |

| | | | | | | |
|--------------|--------------------|------|--------------------|------|--------------------|------|
| HTS | 4.57 ^{bc} | 0.59 | 4.67 ^{bc} | 0.52 | 4.70 ^{ac} | 0.51 |
| HTSC | 4.50 ^{bo} | 0.59 | 4.50 ^{bo} | 0.59 | 4.62 ^{ac} | 0.49 |
| NHT | 4.57 ^{bc} | 0.59 | 4.57 ^{bc} | 0.59 | 4.50 ^{ab} | 0.67 |
| NHTC | 4.50 ^{bo} | 0.67 | 4.52 ^{bc} | 0.59 | 4.50 ^{bc} | 0.55 |
| NHTS | 4.75 ^{co} | 0.49 | 4.75 ^{co} | 0.49 | 4.87 ^{co} | 0.33 |
| NHTSC | 4.62 ^{bc} | 0.54 | 4.60 ^{bc} | 0.54 | 4.72 ^{ac} | 0.50 |
| Total | 4.53 | 0.61 | 4.56 | 0.59 | 4.67 | 0.51 |

Among columns: means with different letters are significantly different

O: Only, HT: Heat treated, C: With citric acid, S: With salt, N: not

3.5.3. Overall acceptability

The SRP paste done with no heat treatment and that with no heat treatment and citric acid addition score the lowest. The others did not differ significantly from each other (Fig.4).

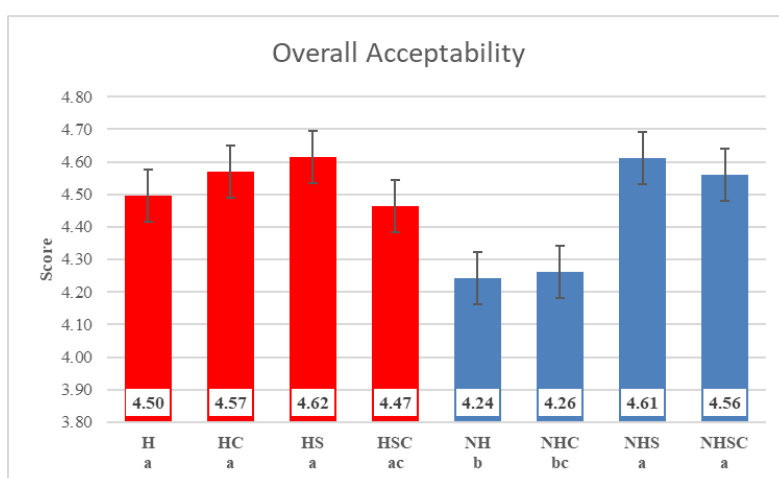


Fig.4 Overall acceptability score of the eight different treatments

H: heat treatment, C: with citric acid, S: with salt, N: no

3.5.4. Spearman correlation results

The overall acceptability score was positively and significantly correlated with all the sensory attributes. The correlation with the color score was the lowest followed by that with the scores of the mouth feel non-mouth feel and texture uniformity and highest with the scores of odor and flavor. Furthermore, it was not significantly correlated with the level of salt and citric acid additions and heat treatment (Table7).

The level salt addition was significantly and positively correlated with the scores of flavor and non-mouth feel.

The level of the heat treatment was significantly related with odor, flavor and mouth feel. It was positively related with flavor and mouth feel scores and negatively correlated with scores of the couth feel (Table 7).

The level of citric acid addition was negatively and significantly correlated with color. The correlation with all the other sensory attributes were not significant (Table 7).

Table 7 Spearman correlation between overall acceptability, level of salt, heat treatment, level of citric acid with the different sensory attributes

| | Overall acceptability | Level of salt | Heat treatment | Level of citric acid |
|--------|-----------------------|---------------|----------------|----------------------|
| Color | 0.292** | -0.088 | -0.055 | -.116* |
| Odor | 0.709** | 0.034 | 0.133* | -0.018 |
| Flavor | 0.854** | 0.143* | 0.165** | -0.034 |

| | | | | |
|-----|---------|--------|---------|--------|
| MF | 0.627** | 0.136 | -0.135* | 0.011 |
| NMF | .624** | 0.161* | -0.087 | -0.034 |
| TU | .602** | 0.134 | 0.03 | -0.067 |
| OA | 1 | 0.123 | 0.101 | -0.047 |

** : Highly significant, * : significant

MF: Mouth feel, NMF: Non-mouth feel. TU: Texture uniformity, OA: Overall acceptability

IV. DISCUSSION

As for the moisture content at 6 hours it was done to choose the practical drying protocol to reach the 20% and accordingly the 6 hours, drying temperature at 70°C was chosen to produce the SRP paste for the tasting trial. This is in accordance to the definition of tomato paste (CODEX STAN 57-1981).

Concerning the water loss, it was noticed that there are two phases, a phase in the first time zone which is from zero to 7 hours and those in the second time zone namely the 8 till 24 hours for both drying temperatures. The curves achieved in this study are similar to those reported by (Kabir & S. Sidhu, 2012). They however did not go for 24 hours. Since they were describing a thin layer drying which is not the case in our study, which started with a 1 cm thick paste. Furthermore, the equations one to six can be used to estimate the drying time needed to get the required moisture content. If we want more accurate results we can use equations one to four which takes into consideration the difference proven for the first eight hours and the next 16 hours. Furthermore, the R² for these equations were 99%. As for equations five and six they can be used but for rough estimations although the R² for both equations were around 96%. Both the 50°C and 70°C are below the 100°C used in completely industrialized paprika paste production. Sodium benzoate had to be used to prevent molding of the product when dried at 50°C. Thus at this drying temperature chemical reactions would occur. At 70°C no molding problem was observed but it was added in order to be able to compare them statistically. So drying at 70°C is much lower than the 100°C and at the same time might reduce the usage of food preservatives.

The level of citric acid was significantly, slightly and negatively correlated with color score. Otherwise, the correlation was not significant with any other sensory attribute. To increase the ease of storage using citric acid with salt is advised since citric acid will lower the pH to less than 4.6 (Table 4) which would make the classification of the paste as high acid food product. Salt addition is might be considered as a natural preservative for the SRP paste. It was positively correlated with the flavor and non-mouth feel and not

significantly correlated with any of the other sensory attributes.

Finally yet importantly, the overall acceptability was not significantly correlated with salt, citric acid or heat treatment which increases the possibility of their usage.

V. CONCLUSION

The results of this study suggested that if drying temperature around 50°C an anti-mold preservative should be used, while this is not necessary at drying temperature of 70°C. Furthermore, the drying stages should be divided into two to get results that are more reliable. The citric acid addition, salt addition and heat treatment had no effect on the flavor and color and most importantly on the overall acceptability of the SRP paste. Now the preliminary technical information is available and this is important basis to design further studies on traditional food that follow the same protocol.

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